

EOCENE NEOSELACHIANS FROM THE LA MESETA FORMATION, SEYMOUR ISLAND, ANTARCTIC PENINSULA¹

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ABSTRACT: Neoselachian teeth from the La Meseta Formation, Seymour Island, Antarctic Peninsula, include those of the following taxa: *Carcharodon auriculatus* (Blainville 1816), *Eugomphodus macrota* (Agassiz 1843), Lamnidae indeterminate, Squalidae indeterminate, *Squatina* sp., and Myliobatoidea indeterminate.

The lamniforms *Eugomphodus macrota* and *Carcharodon auriculatus* are cosmopolitan species and indicate a middle to late Eocene and possibly early Oligocene age for the La Meseta Formation.

INTRODUCTION

During the austral summer of 1974-1975, a joint field party from the Institute of Polar Studies at The Ohio State University and the Argentine Antarctic Institute visited Seymour Island, located on the northeast side of the Antarctic Peninsula. A geological survey of the Tertiary sequence at the northern end of Seymour Island was undertaken by William Zinsmeister and, during the course of the season, a small collection of shark and ray teeth was made from Unit II of the La Meseta Formation. The fossils are deposited in the Museum of Paleontology of the University of California, Berkeley (UCMP) and in the Institute of Polar Studies at The Ohio State University, Columbus, Ohio. The description and taxonomic evaluation of these fossils constitute the basis for this paper.

REVIEW OF PREVIOUSLY DESCRIBED SHARKS FROM SEYMOUR ISLAND

Cretaceous and Eocene fishes were first collected from Seymour Island by the Swedish South Polar Expedition between the years 1901 and 1903. Woodward (1906) described several large selachian vertebrae from Cretaceous material contained in the above collection and referred them to the genus *Ptychodus* Agassiz (1835). He based this identification upon shared characters of internal and external calcification observed in the Seymour Island specimens and in vertebrae found in association with fossil teeth of *Ptychodus decurrens* Agassiz 1835 from the English Chalk (Woodward 1902:228-29, pl. 52, fig. 6). The presence of large, biconcave vertebrae with a very short anteroposterior length, thin concentric calcified lamellae with perforated walls within each intermedialia, weakly developed radii, and basilia for neural and hemal arch cartilages are characters that Woodward (1906:1-2) used to diagnose vertebrae of *Ptychodus*. As Woodward (1902:229) noted, this calcification pattern is also very similar to that found in vertebrae of *Corax* (= *Squalicorax*). In addition, concentric calcification patterns are also known in modern and fos-

sil species of the basking shark *Cetorhinus* (Hasse, 1882, pl. 32, figs. 1-8; Ridewood 1921:360, fig. 13a; White 1935:79), the angel shark *Squatina* (Ridewood 1921:376-78, fig. 25b), and the whale shark *Rhincodon typus* (White 1930:136, pl. 29, fig. m).

Vertebrae found in association with teeth of *Ptychodus chapPELLI* Reinhart (1951) from the Turonian of San Luis, Tolima, Colombia (UCMP 39525), possess numerous thin concentric lamellae; however, the vertebrae are proportionately anteroposteriorly longer and dorsoventrally shorter than those attributed to *Ptychodus* by Woodward (1902:228-29) from either the English Chalk or the Cretaceous rocks of Seymour Island. At present, articulated skeletons of *Ptychodus* are not known, and the finding of teeth and vertebrae in association should not be regarded as demonstrable proof that all are from the same genus.

The presence of relatively undistorted concentric calcifications in the vertebrae from Seymour Island (Woodward 1906, pl. 1, figs. 1-3) suggests that their short anteroposterior length is not due to compression from sediment load. In most respects, the Seymour Island vertebrae resemble those found in an articulated skeleton of *Squalicorax* cf. *S. kaupi* from the Niobrara Formation of Kansas (Section of Vertebrate Paleontology, Natural History Museum of Los Angeles, County, LACM 120090). In light of the above data, continued allocation of the Seymour Island vertebrae to the genus *Ptychodus* must be considered tenuous.

Elliot et al. (1975) were the first to mention the occurrence of fossil shark teeth in the early Tertiary rocks of Seymour Island. Subsequently, del Valle et al. (1976:8) identified *Scapanorhynchus raphiodon* (Agassiz) 1844, *S. subulatus* (Agassiz) 1844, *Isurus mantelli* Agassiz 1843, *Isurus* sp., and *Carcharias* sp. based upon a small number of fragmentary shark teeth from the La Meseta Formation. Unfortunately, their taxonomy was based largely upon Ameghino's incorrect identifications of teeth from the Patagonian marine formation of Argentina (Ameghino 1906). Cione et al. (1977:9-14) published the first comprehensive description of sharks from the La Meseta Formation and recognized three genera and two species: *Eu-*

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gomphodus macrota (Agassiz 1843), *Isurus novus*? (Winkler 1873), and *Procarcharodon* Casier 1960. As a result of the present study, five taxa of neoselachians are recognized from Unit II of the La Meseta Formation. In addition to *Carcharodon auriculatus* and *Eugomphodus macrota*, the angel shark *Squatina*, an indeterminate squaloid close to *Centrophorus* Müller and Henle 1837, and a myliobatoid ray are recorded for the first time.

LOCALITY

UCMP V77014, Seymour Island, Antarctic Peninsula, 64°15'S, 56°45'W. Fossil shark and ray teeth were collected from a coarse, pebbly, fossiliferous shell bank in Unit II of the La Meseta Formation, approximately 150 m above the base of the Seymour Island Series on the north side of the island, directly across from Corkburn Island (6.5 km east, 3 degrees from Bodman Point and 4.1 km south, 61 degrees from Cape Wiman). The shell bank, being slightly more resistant to weathering, forms a distinct break in slope that can be traced for several kilometers along strike (Fig. 1).

STRATIGRAPHY

The sequence of tertiary rocks on Seymour Island was first described by Anderson (1906). He proposed the name "Seymour Island Series" for the loosely consolidated sands and sandy siltstones of Tertiary age at the north end of the island (Fig. 1). Elliot and Trautman (in press) have proposed that the term "Seymour Island Series" be dropped in favor of "Seymour Island Group," which includes the Cross Valley and La Meseta Formations.

Since the present paper is primarily concerned with the fossil shark assemblage in the La Meseta Formation, only a brief description of the Cross Valley Formation is given. For a more detailed description of the stratigraphy of the Cross Valley Formation, see Elliot and Trautman (in press). The Cross Valley Formation crops out in a series of fault splinters in Cross Valley (Fig. 1). It consists of approximately 105 cm of immature sandstones and pebbly sandstones unconformably overlying the Upper Cretaceous "Snow Hill Island Series." The sands of the Cross Valley Formation contain a high percentage of volcanic glass and pumice with locally abundant concentrations of fossil wood and plant debris near the base, and the Cross Valley Formation is interpreted as representing a predominantly non-marine deltaic deposit. The presence of marine molluscs near the top of the formation indicates that its uppermost part is marine.

The La Meseta Formation consists of at least 450 m of loosely consolidated sandstones, sandy siltstones, and interbedded conglomerates. Discontinuous concretionary horizons are present throughout the section. Elliot and Trautman (in press) have informally divided the formation into three lithologic units. Unit I, near the base of the formation, consists of at least 160 m of unconsolidated fine sands and silty sands. Unit II consists of approximately 200 m of fine laminated sands with prominent discontinuous fossiliferous conglomerates that may extend for a kilometer along strike. These highly fossiliferous

conglomerates are interpreted as representing accumulations in a nearshore, high-energy marine environment. All the shark material described in this paper was surface-collected from the lowermost shell banks at the base of Unit II. Local cross-bedding, oscillation ripple marks, and small to large cut and fill channels are present in the finer grained facies of Unit II.

Unit III, the upper 80 to 125 m of the La Meseta Formation, is characterized by fine sands with intervals of fine clays and sandy gravel horizons. All fossil penguin material collected during the 1974-1975 field season came from Unit III (Elliot et al. 1975). The invertebrate fauna of this unit differs significantly from that of Units I and II; the differences are of such a magnitude (Zinsmeister and Camacho, in press) that a hiatus of unknown duration may have occurred between the deposition of material in Units II and III.

AGE AND CORRELATION

There has been considerable controversy over the age of the Tertiary rocks on Seymour Island. Until recently, Antarctic workers have accepted Wilckens (1911) assignment of the sequence to the Miocene. Ihering (1927) suggested that the molluscan faunas from Seymour Island were Eocene, and this interpretation has been confirmed for at least part of the sequence in a recent series of papers (Simpson 1971; Zinsmeister 1977, 1978; Hall 1977). It appears from the available data that the Tertiary rocks on the island range in age from Paleocene (Cross Valley Formation) to late Eocene to possibly lowermost Oligocene (La Meseta Formation), with the Early Eocene missing.

The presence of two species of nautiloids (*Aturia* sp. and *Eutrephoceras argentiniae* del Valle and Fourcade 1976) supports Simpson's 1971 assignment of the La Meseta Formation to the Eocene. *Aturia* sp. from Unit II is very similar to *A. bruggeni* Ihering from the Eocene of Tierra del Fuego. The occurrence of the genus *Eutrephoceras* in the La Meseta Formation is an important indication of the age of the fauna. Except for a single species of *Eutrephoceras* in the Oligocene from the west coast of North America, the genus is confined to the Paleocene and Eocene of the western hemisphere (Zinsmeister and Camacho, in press). In a discussion of some remarkably well-preserved specimens of *Eutrephoceras* from the La Meseta Formation, Zinsmeister (1978) showed that *E. argentiniae* is very similar to the Eocene *E. allani* Fleming from New Zealand.

The data summarized in this study and the joint occurrence of two cosmopolitan lamnoid species, *Carcharodon auriculatus* and *Eugomphodus macrota*, in Unit II of the La Meseta Formation strongly suggest a middle to late Eocene age (Lutetian to Bartonian Correlative) for Unit II deposits. A middle to late Eocene age is also indicated for Unit III by the occurrence of a mandible of an archaeocete whale at this horizon (Elliot et al. 1975).

The shark and ray assemblage of Unit II of the La Meseta Formation falls within the stratigraphic interval included in the provisional *Antarctodarwinella nordenskjoldi* molluscan zone of Zinsmeister and Camacho (in press). Examination of palynomorphs from Seymour Island suggests that the La Meseta Formation is correlative with the Rio Turbio Formation of

southwest Patagonia and the Lena Dura Formation of Tierra del Fuego (Hall 1977).

SYSTEMATIC PALEONTOLOGY Family Squalidae Leach 1818 Genus and species indeterminate

Figure 2

REFERRED SPECIMEN: UCMP 121795, one worn lower left anterolateral tooth lacking most of the root and labial crown flange.

DESCRIPTION: Tooth large, mesodistal crown length 6.02 mm; cusp broad-based, triangular, and distally inclined at an angle of 53 degrees; mesial cutting edge weakly sinuous, almost straight and smooth; distal cutting edge weakly convex and basally serrated; distal blade well developed, apically flat with low distobasal inclination, and mesially serrated; cusplets absent; labial flange present, but size, shape, and basal development indeterminate because of poor preservation and breakage; labial crown root forming moderately strong ledge and bordered basally by five foramina on the distal root lobe; lingual

crown face very badly eroded, obscuring all details of the central lingual foramen, lingual protuberance, and crown-root relationships; distal crown depression well developed as in *Centrophorus* and many other squaloids; root almost completely absent and lacking all taxonomically significant characters.

DISCUSSION: The intermediate apicobasal crown height, moderate distal cusp inclination, presence of a well-developed distolingual depression for the articulation of the adjacent (next distal) tooth, and absence of cusplets are characters that, when taken in combination, distinguish this specimen from upper or lower teeth belonging to species of *Centroscyllium*, *Etmopterus*, *Dalatias*, *Scymnodon*, *Heteroscyrnoides*, *Scymnodalatias*, some *Centroscyrnus*, *Oxynotus*, *Squaliolus*, *Euprotomicrus*, *Euprotomicroides*, *Aculeola*, *Somniosus*, and *Isistius*. The absence of a distinct short and detached flange, the height of the distal root lobe (as preserved), and the presence of a strong distolingual depression separate this specimen from *Squalus*, *Centrosqualus*, and *Cirrhigaleus*. In most characters, UCMP 121795 most closely resembles the lower anterolateral teeth of *Centrophorus* or *Deania*.

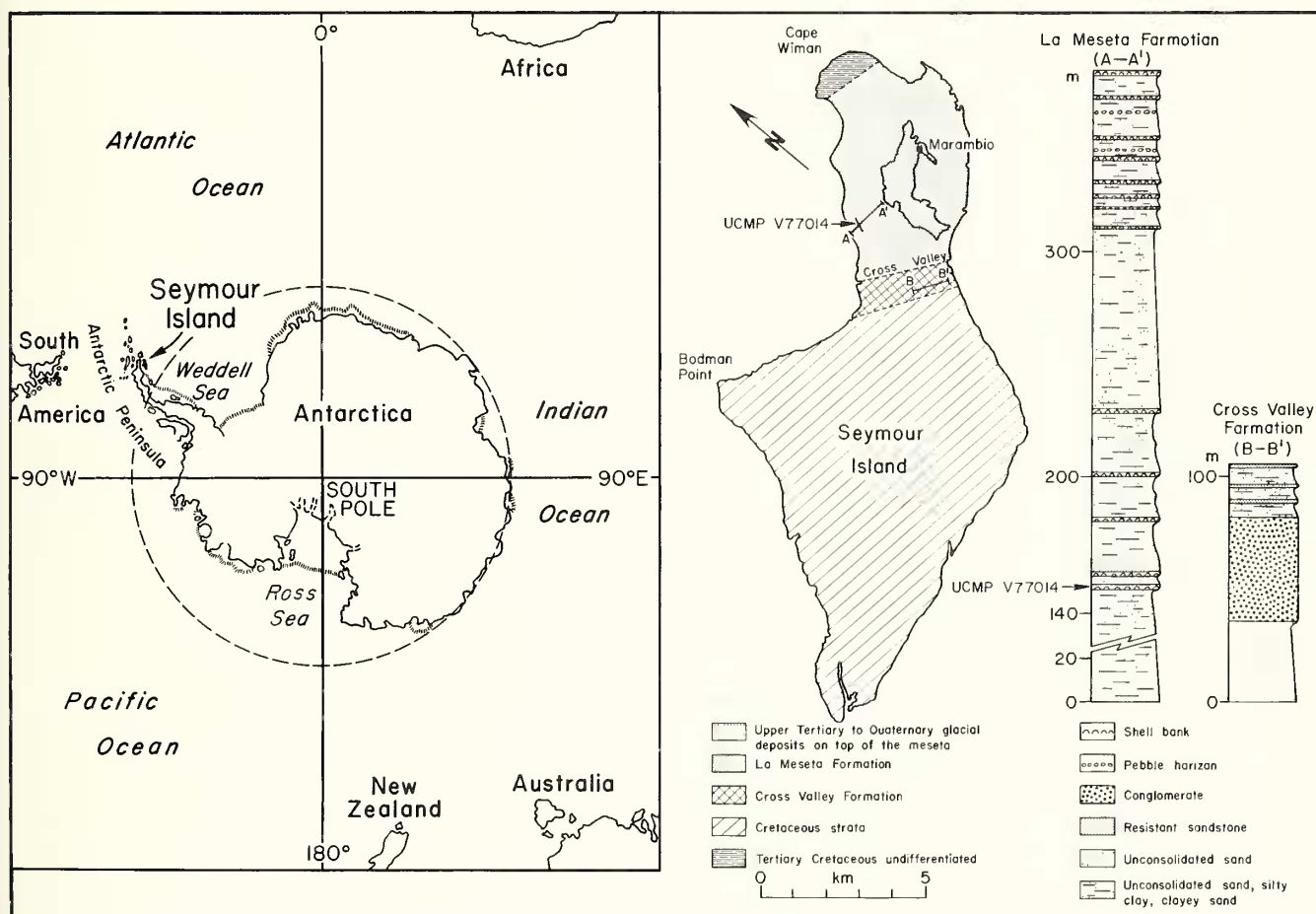


Figure 1. Index map and geologic map showing the distribution of the Cretaceous, Tertiary, and Quaternary rocks on Seymour Island, Antarctic Peninsula. The collecting locality, UCMP V77014, for the fossil sharks described in this paper is shown on both the map and the stratigraphic section A-A'.

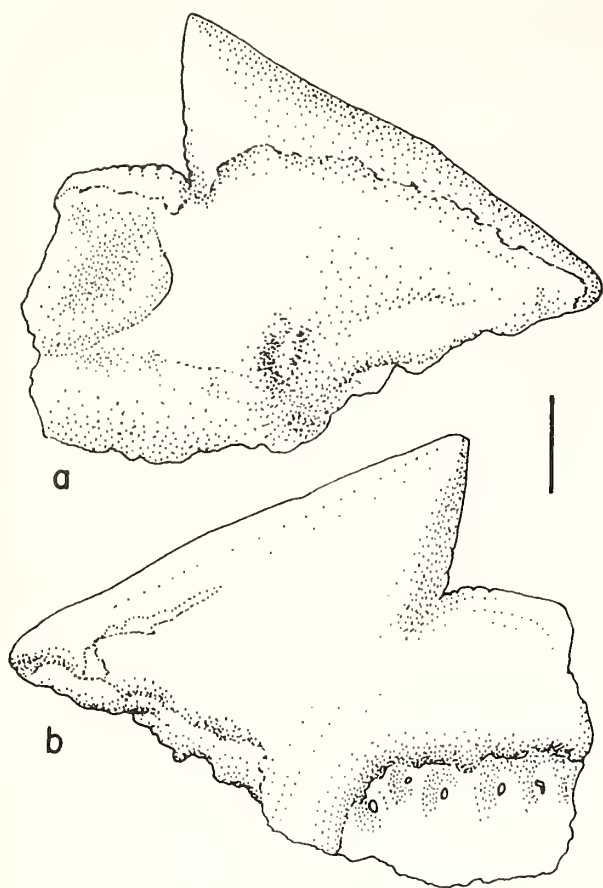


Figure 2. Squalidae, genus and species indeterminate, UCMP 121795; incomplete lower left anterolateral tooth: **a**, lingual view; **b**, labial view. Scale line = 1 mm.

Root morphology is extremely important for determination of specific, generic, and subfamilial levels of identification among the Squalidae. The incomplete root in the Seymour Island specimen precludes a more specific identification.

Family Squatinidae Bonaparte 1838

Genus *Squatina* Risso 1810

Squatina sp.

Figure 3

REFERRED SPECIMENS: UCMP 121796, one incomplete tooth with a worn cusp apex and lacking tip of mesial root lobe; UCMP 121797, one incomplete tooth with a badly eroded root and lacking cusp apex.

DESCRIPTION: Teeth small, mesodistal root length $5.16 \pm$ mm (UCMP 121796) and $4.94 \pm$ mm (UCMP 121797); apicobasal tooth height $3.58 \pm$ mm (UCMP 121796) and $2.59 \pm$ mm (UCMP 121797); cusp short, broad based, weakly inclined distally, and weakly recurved labially; lingual and labial faces strongly convex, smooth; transverse ridges and grooves absent; labial flange weak, basally rectangular (as preserved, UCMP

121796) or weakly rounded (UCMP 121797), with a strong, short median apicobasal ridge on the labial flange face that does not extend onto cusp; mesial and distal cutting edges of cusp continuous from apex to mesial and distal edges of blades; blades low and narrow; root typically *Squatina*; central lingual protuberance prominent with a strongly developed labiolingual ridge extending to crown foot and laterally below each blade; lateral root ridges bordered by numerous irregular foramina (UCMP 121796); large foramina on apicolingual surface of root prominence; basal face of root moderately concave with a very large central basal foramen; labial root face apicobasally low with deep grooves paralleling crown foot both mesially and distally.

DISCUSSION: UCMP 121796 is distinguished from *Orectolobus* Bonaparte 1837 and similar to *Squatina* in having a short tapering cusp, in lacking an elevated mesial or distal blade, in having mesodistally narrow rather than expanded and tabular root lobes; and in possessing a deep pit rather than a shallow, generally triangular, lingually pointed transverse groove on the midline of the labiobasal root surface.

Features of the crown shape—its short broad base, apically acute cusp, short and rectangular labial flange, and moderately concave basal root face—are characters that appear to separate these specimens from the Paleocene-Eocene *Squatina prima* (Winkler 1873), as well as from all other nominal fossil species of *Squatina*.

Difficulties in recognizing dental differences between species of *Squatina* are best overcome by analysis of large numbers of teeth. It is our contention that the poorly preserved Seymour Island specimens do not provide a sufficient morphological basis for such an analysis and that it would not be prudent at this time to make a specific determination.

Family Odontaspidae Müller and Henle 1841

Genus *Eugomphodus* Gill 1861

Eugomphodus macrota (Agassiz, 1843)

Figures 4g through p

SYNONYMS: *Otodus macrotus* Agassiz 1843:273. *Lamna elegans* Agassiz 1843:289. *Odontaspis* (*Synodontaspis*) *macrota* Casier 1946:66. Casier 1958:18. *Striatolamia macrota* Glickman 1964:102. *Odontaspis* (*Synodontaspis*) *macrota* Casier 1966:69-71. *Odontaspis macrota* Applegate 1968:32-36. *Odontaspis* (*Synodontaspis*) *macrota* Edwards and Stinton 1971:449-53. *Odontaspis macrota* Cione et al. 1977:10. For a more extensive synonymy encompassing the years 1889-1946, see Casier 1946:66.

REFERRED SPECIMENS: UCMP 116454-58, incomplete anterior teeth; UCMP 116459 and 116460, incomplete lateral teeth; and 225 broken tooth crowns in the collection of The Ohio State University, Institute of Polar Studies.

DESCRIPTION: The sample includes numerous broken anterior and lateral teeth (tooth group terminology follows Applegate 1965 and Compagno 1970). Symphyseals, intermediates, and posteriors are not present in the sample. Crowns of the anterior teeth are small (15 mm, UCMP 116456) to very large ($54 \pm$ mm, UCMP 116454); A^2 , A^3 , and $?L^1$ mesiodistally very broad and labiolingually compressed. Labial faces weakly con-

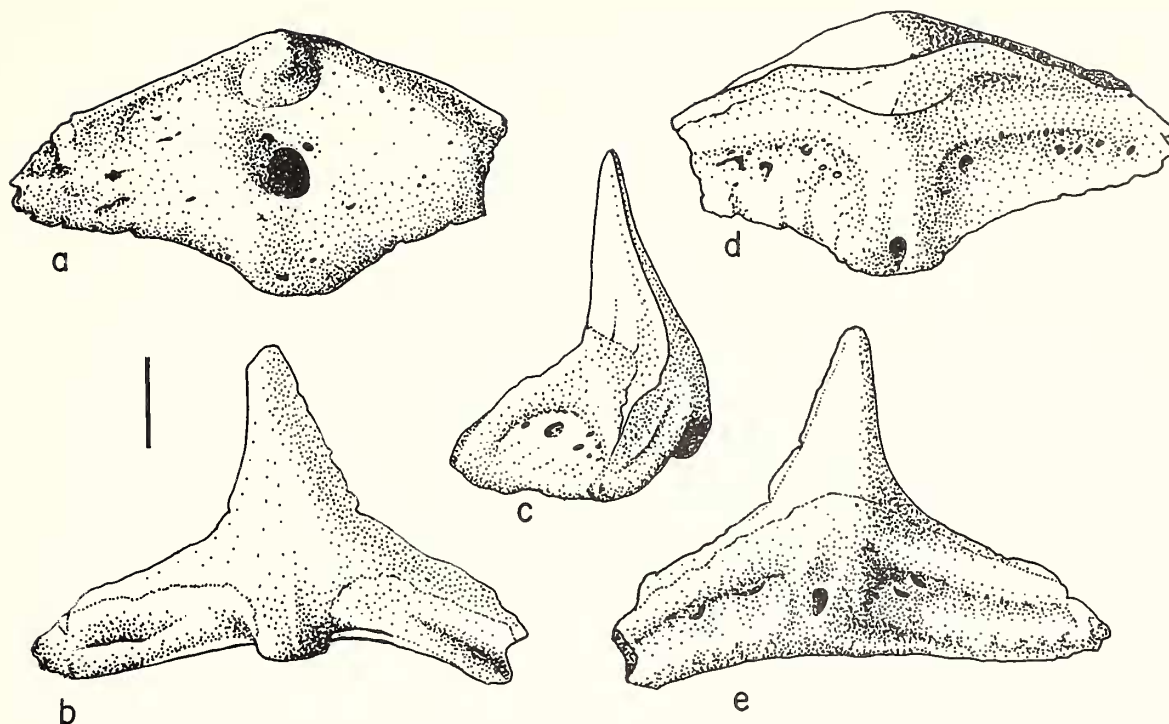


Figure 3. *Squatina* sp., UCMP 121796; anterolateral tooth; a, basal view; b, labial view; c, distal view; d, apical view; e, lingual view. Scale line = 1 mm.

vex or almost flat; crown foot nearly smooth (UCMP 116454 and 116458) or with well-developed, short, shallow to deep transverse grooves extending from the crown foot in an apical direction for a distance of approximately 5 to 13 percent of the crown height (UCMP 116455, 116459, and 116460); lingual face moderately to strongly convex just apical to crown foot; lingual transverse ridges parallel to subparallel, strong (UCMP 116455, 116457) to weakly developed (UCMP 116454, 116458–60) and extending from crown foot almost to cusp apex (UCMP 116458) or well developed near crown foot and becoming very faint toward distal half of the crown; mesial and distal cutting edges extend from crown apex to crown foot in laterals (UCMP 116459 and 116460) but are not continuous to crown foot in any of the anterior tooth positions; cusplets of anteriors very small, conical—there is only one on the mesial and distal edges of the crown foot; lingual neck (term after Glickman 1964a and b) narrow but well developed on all anterior teeth; roots robust, anteriors with weak to strong lingual protuberance; root morphology variable according to tooth position.

DISCUSSION: Although none of the teeth are complete, most of the important morphological characters are well enough preserved to allow for definitive taxonomic assignment. In combination, the broad flat lingual crown face with weakly developed transverse ridges, one pair of small conical lateral cusplets, large and robust lingual protuberance, nearly flat or weakly concave labial crown face, and extremely large anterior and lateral teeth are characters consistent with *Eugomphodus*

macrota (Agassiz 1843) and separate this taxon from all other species of *Eugomphodus*.

Family Lamnidae Müller and Henle 1838
Genus *Carcharodon* Müller and Henle 1841
Carcharodon auriculatus (Blainville 1816)

Figures 4a through c

SYNONYMS: *Squalus auriculatus* Blainville 1816:384. *Carcharodon auriculatus* Agassiz 1843:254. *Procarcharodon auriculatus* Casier 1960:13. *Otodus auriculatus* Glickman 1964a:114–16. *Carcharodon auriculatus* Keyes 1972:237–40. *Procarcharodon* sp. Cione et al. 1977:13.

REFERRED SPECIMEN: UCMP 116453, an incomplete anterior tooth lacking one cusplet, portions of both root lobes, and part of the lingual crown foot and neck.

DESCRIPTION: Tooth large, greatest apical basal length 70+ mm (as preserved, apex of cusp worn); crown high and narrow, labial face smooth, moderately convex on mesial and distal edges, nearly flat or slightly concave along the central axis just above crown foot; labial face of crown strongly convex; transverse grooves and ridges absent; mesial and distal cutting edges coarsely serrated; serrations badly worn but appear to have been pointed; cutting ridges extend basally to crown foot and are continuous with one large coarsely serrated, bladelike, bi-convex cusplet (one cusplet missing); root bilobate and narrow but too poorly preserved to warrant further description.

DISCUSSION: In combination, a high narrow crown, coarse

pointed serration, and large lateral cusplets are characteristic of Paleogene and early Neogene species of *Carcharodon* (= *C. auriculatus* and *C. angustidens* Agassiz). *Carcharodon auriculatus* has higher and narrower crowned anterior teeth than *C. angustidens*, and UCMP 116453 is tentatively referred to the former species.

Since the early 1800's, approximately 54 nominal fossil species of *Carcharodon* have been described, and many have subsequently been recognized as junior synonyms of *C. megalodon* Agassiz. Many of the remaining nominal species are of questionable validity, and their phylogenetic relationships to one another and to the modern species of the genus *Carcharodon*, as

well as the interrelationships of the latter genus to all other members of the Lamniformes, are poorly understood.

Casier (1960) deduced that the fossil species of *Carcharodon* could be divided into two genera (*Procarcharodon* and *Carcharodon*) based entirely on the morphology of the teeth. As a result, he removed all Paleogene and Miocene and some Pliocene species from the genus *Carcharodon*, leaving it composed of "phyletically interrelated" Pliocene to Recent species. Based on this interpretation, Casier derived modern *Carcharodon* from early *Isurus hastalis* (*Oxyrhina hastalis*) and then recognized a separate lineage for the remaining species of *Procarcharodon*. Casier's study necessarily emphasized the

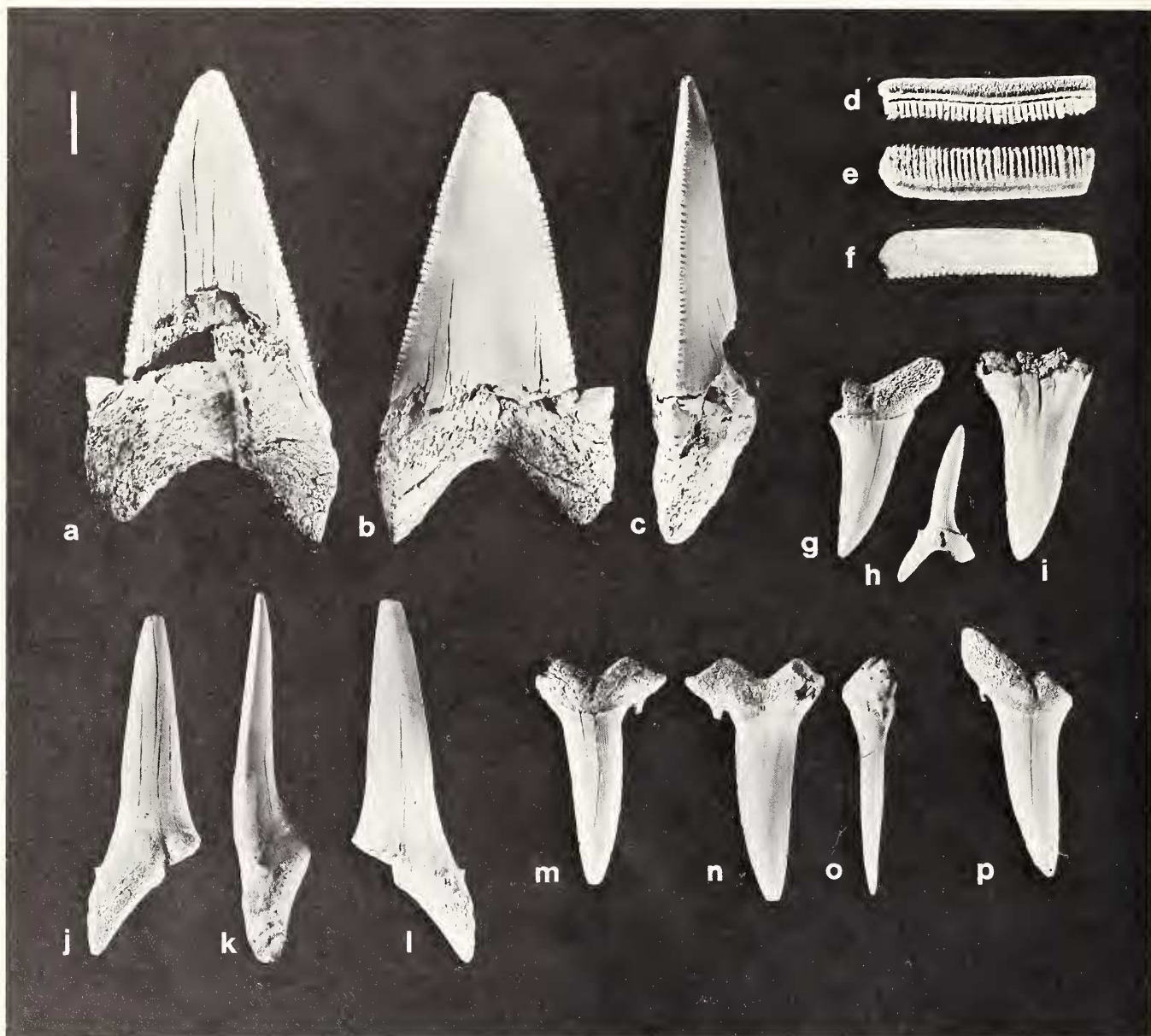


Figure 4. *Carcharodon auriculatus* (Blainville 1816), UCMP 116453; **a**, lingual view; **b**, labial view; **c**, distal view; Myliobatoidea family indeterminate, UCMP 116461; **d**, lingual view; **e**, basal view; **f**, apical view; *Eugomphodus macrota* (Agassiz 1843); **g**, UCMP 116459, lingual view; **h**, UCMP 116456, lingual view; **i**, UCMP 116460, labial view; UCMP 116454; **j**, lingual view; **k**, distal view; **l**, labial view; UCMP 116455, **m**, lingual view; **n**, labial view; **o**, mesial view; **p**, UCMP 116458, lingual view. Scale line = 10 mm.

dentition, because teeth form the major part of the fossil record, but no attention was paid to details of ontogeny and comparison of homologous tooth positions, or most importantly, dental formulae. We do not find Casier's interpretations convincing, and we agree with Keyes (1972) that the similarities between *I. hastalis* and *Carcharodon* (in the restricted sense of Casier 1960) might be indication of convergence rather than phylogenetic relationship. The phylogeny of *Carcharodon* is best interpreted through detailed analysis of tooth morphology and dental formulae using specimens collected only under conditions of demonstrable superpositional control. A detailed study of ontogenetic heterodonty in the living *C. carcharias* and *Isurus* spp. would be extremely useful in resolving these problems. We have chosen to retain the older nomenclature of *Carcharodon* and reject, at this time, placement of *C. auriculatus* in the genus *Procarcharodon* Casier.

Superfamily Myliobatoidea Compagno 1973

Family Indeterminate

Figures 4d through f

REFERRED SPECIMEN: UCMP 116461, one incomplete medial tooth lacking distal end of crown and one side of root.

DESCRIPTION: Isolated, worn medial plate of typical myliobatoid morphology with a smooth (as preserved) occlusal crown surface and polyaulacorhizous root (as defined by Casier 1947c). Tooth not chevron shaped in occlusal or basal view as in the upper dentition of *Aetobatis* Blainville (see Garman 1913, pl. 49, figs. 1-3) but mesiodistally straight as in *Myliobatis* Cuvier 1817, *Aetomylaeus* Garman 1908, *Pteromylaeus* Garman 1913, and *Rhinoptera* Cuvier 1829. Occlusal surface of tooth weakly concave in labial or lingual view—apicobasal height only slightly greater in middle of tooth than at either mesial or distal end.

DISCUSSION: Approximately 118 nominal fossil species of myliobatoid rays have been described from Cenozoic marine deposits throughout the world. Of the five extant genera of myliobatoid rays, *Aetomylaeus* has never been reported from the fossil record. The apparent absence of a paleontological record for this genus is a result of our past and present inability to recognize generic differences in myliobatoid dentitions. Most isolated or associated ray plates have been assigned to a species in the genus *Myliobatis*, and what appears to be high specific diversity among Cenozoic *Myliobatis* (approximately 91 nominal species) is in reality an artifact of this procedure. No doubt, the 91 species are indicative of extreme oversplitting brought about by (1) misinterpretation of individual variation for specific differences, (2) failure to decipher patterns of heterodonty, and (3) failure to understand the comparative dental morphology of extant myliobatoids.

A preliminary analysis of over 300 individual jaws of the extant California bat stingray *Myliobatis californicus* Gill from two populations along the central and northern California coasts revealed that the arrangement of tooth row-groups and the number and morphology of teeth in each row are highly variable (results of research by Leonard J.V. Compagno, Tiburon Center for Environmental Studies, and Welton). In fact, the range of variation within the tooth row-group pattern

found in *Myliobatis californicus* transcends virtually all supposed "generically distinct" dental patterns of other myliobatoid rays (including the lower but not the upper dentition of *Aetobatis*). In addition to displaying a surprisingly high level of polymorphism, the *M. californicus* specimens have dental abnormalities that range from total disruption of the typical row-group pattern (some jaws bore a superficial resemblance to those of the dasyatid "*Hypolophus* Müller and Henle") to the presence of sinuous medials bearing the primary generic characters of the Maestrichtian genus *Igdabatis* Cappetta 1972 (this same developmental abnormality also occurs in *Rhinoptera steindachneri* Evermann and Jenkins (1892), and a weakly developed version of it was illustrated by Gudger (1933:75, fig. 10) for a Pliocene specimen of *Myliobatis crassus* Gervais 1859). Analysis of the large sample also revealed the presence of dental sexual dimorphism: Males had labiolingually shorter teeth than females of equivalent size. This finding has particularly strong implications, as length-width ratios of fossil teeth have been used as a method for distinguishing one taxon from another. In *M. californicus*, at least, the length-width ratios of teeth in the same row in the same jaw may vary widely, suggesting, among other things, seasonal variation in the rate of tooth production (Leonard J.V. Compagno, personal communication).

It appears at this time that specific assignment of UCMP 116461 by comparison with fossil dentitions of equivalent or different age would have practically no validity and that its placement in the superfamily Myliobatoidea without generic allocation provides the best arrangement.

DISCUSSION AND CONCLUSIONS

The sharks from the La Meseta Formation that were described but not illustrated by del Valle et al. (1976) were all incorrectly identified according to the redescription and reidentification of the same specimens by Cione et al. (1977). According to the latter authors, the shark assemblage of the La Meseta Formation includes *Eugomphodus macrotus*, *Eugomphodus* sp., *Isurus novus*?, *Isuridae* indet., and *Procarcharodon* sp.

We recognize the occurrence of *Eugomphodus macrotus* and *Carcharodon* (= *Procarcharodon* of Cione et al. 1977) in the La Meseta Formation, and a well preserved tooth of *Carcharodon* is more specifically referred to *Carcharodon auriculatus*. A tooth shown by Cione et al. (1977, fig. 3g) and identified as *Isurus novus*? is too poorly preserved in our opinion to warrant specific or generic identification and should be included under *Lamnidae* indeterminate. Teeth referred to *Eugomphodus* sp. (Cione et al. 1977, fig. 3a and b) are probably *Eugomphodus macrotus*. One indeterminate squaloid tooth, two poorly preserved teeth of *Squatina* sp., and disassociated pavement teeth of a myliobatoid or rhinopterid stingray are new additions to the neoselachian assemblage of the La Meseta Formation. The total fossil shark assemblage from the La Meseta Formation, therefore, now includes *Eugomphodus macrotus*, *Carcharodon auriculatus*, *Lamnidae* indeterminate, *Squalidae* indeterminate, *Squatina* sp., and Myliobatoidea genus and species indeterminate.

The geologic range of *Carcharodon auriculatus* differs depending on whether the species is broadly or narrowly interpreted. According to Casier (1960:13), *C. auriculatus* ranged approximately from middle to upper Eocene, and the species ultimately evolved into *C. angustidens* in the Oligocene. *Carcharodon auriculatus* was a cosmopolitan taxon and has been reported from the Eocene and Oligocene of New Zealand (Keyes 1972:238), from the middle and upper Eocene of North America, Europe, and Africa (Avnimelech 1959:36-37, Casier 1960:13), and the Oligocene of Europe (Leriche 1910:291) and Patagonia (Ameghino 1906:181). According to Glickman (1964b), "*Otodus auriculatus*" occurs in deposits of Paleocene to middle Oligocene age in the Volga area and the Ukraine, Caucasus, and Kazakhstan. Reports of *Carcharodon auriculatus* from the Oligocene to lower Miocene of Australia (Chapman and Pritchard 1904; Chapman and Cudmore 1924; Pledge 1967) may actually represent records for *C. angustidens*.

According to Casier (1946:67), *Eugomphodus macrota* (Agassiz) has been reported from deposits of Ypresian to Bartonian age in Belgium, Northern France, the Paris Basin, and England and from deposits of Lutetian age in Africa. Teeth of *Eugomphodus macrota* are abundant in deposits of Lutetian and Bartonian age in California and Oregon (Welton, unpublished data) and have also been reported from the Eocene of the east coast of North America (Leriche 1942), Chile (Schneider 1936), and the Volga Area, Ukraine, Central Asia, and Kazakhstan (Glickman 1964a and b).

The three nonlamnoid taxa in the La Meseta Formation are too incompletely known at this time to allow comparisons with faunas elsewhere. Generally, myliobatoid rays and *Squatina* are well represented in most Cenozoic neoselachian assemblages. The tooth referable to ?*Squalinae* is of interest as it appears to represent a non-*Squalus* squaloid—a taxon that has not been recorded previously from Cenozoic rocks of South America, New Zealand, or Australia.

ACKNOWLEDGMENTS

We thank the University of California's Museum of Paleontology for support of this study and the University's Department of Paleontology for use of their photographic darkroom.

This study was aided by the staff of the Section of Vertebrate Paleontology, Natural History Museum of Los Angeles County. We are particularly grateful to Mrs. Dianne McDonald and Mrs. Betty Marsh for sorting and picking fossils from bulk matrix samples of the La Meseta Formation. The line drawings and photographs were prepared by Welton. We also express our gratitude to Argentina's Direccion Nacional del Antartico and Instituto Antartico Argentino for their field support of Zinsmeister during the 1974-1975 field season. This work was also supported by National Science Foundation Grant OPP74-21509 to The Ohio State University and the Institute of Polar Studies.

We also thank Mr. David Ward, Dr. Leonard J.V. Compagno,

and Dr. Lawrence G. Barnes, for critically reading the manuscript.

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Accepted for publication 19 June 1980.